Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2015/057

EVALUATION OF MARINE RECREATIONAL COHO MARK-SELECTIVE FISHERIES

Photo: Marine Coho Salmon — provided by Fisheries and Oceans Canada

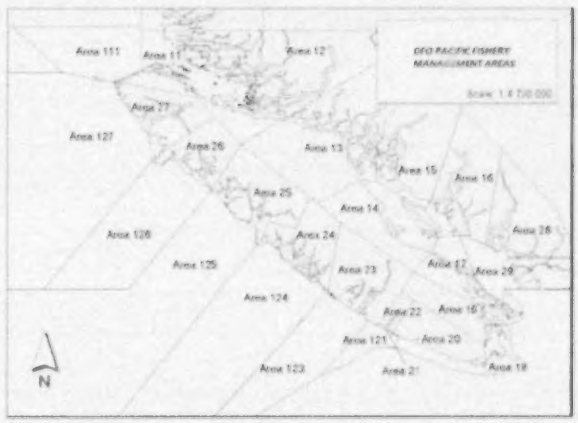

Figure 1. Pacific Fishery Management Area Map, southwestern British Columbia. Mark Selective Fisheries occur in many of these areas.

Context:

The management objective of mark-selective fisheries (MSF) is to allow the retention of marked, often hatchery-produced, fish while having a reduced impact relative to a non-mark-selective fishery on unmarked, usually wild, fish. Minimizing impact on wild fish is important as they often represent the portion of the population most valuable for maintaining genetic diversity or other conservation objectives, such as stock rebuilding. While potentially useful, MSF are costly to conduct and can interfere with other monitoring efforts such as the coded wire tag programs currently conducted through various Fisheries and Oceans Canada (DFO) sectors. Fisheries Management and the Salmon Enhancement Program have requested that Science Branch conduct a review of the Coho MSF program to evaluate their effectiveness and utility as management tools. This assessment, and advice arising from this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR), will be used to inform the overall evaluation of the MSF program, the development of Integrated Fisheries Management Plans (IFMPs) for southern BC salmon and assessment of IFR Coho.

This Science Advisory Report is from the March 3-5, 2015 regional peer review on the Evaluation of Marine Recreational Coho Mark-selective Fisheries in British Columbia, including an evaluation of the Canadian marine fishery exploitation model for Interior Fraser Coho. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

December 2015

Canada

SUMMARY

- Declines in the abundance of southern British Columbia Coho salmon populations, in particular Interior Fraser River Coho (IFR) salmon, through the 1990's, resulted in harvest restrictions for Coho in all sectors beginning in 1998. Mark-selective fisheries (MSF) were implemented under a domestic operational target exploitation rate ceiling for IFR Coho Salmon. Pre-season planning of mixed stock fisheries, where IFR Coho were prevalent, was limited to an exploitation rate for IFR Coho of 3%, through 2013 and, in 2014, up to 16% in Canadian domestic fisheries.
- Theoretical evaluation and simulation modeling indicate that MSFs can reduce exploitation rates on unmarked fish relative to a fishery that is not mark-selective. Mortality rates for unmarked fish depend not on capture mortality, but mortality experienced from hooking and releasing, or from interaction with fishing gear that doesn't result in capture. A MSF will have a lower exploitation rate on unmarked fish than a non-MSF, as long as the mortality rate from release or gear interactions for unmarked fish is lower than the proportion of marked fish in the fished population.
- One of the primary concerns of using MSFs is the potential to complicate stock assessment, especially the use of coded wire tags (CWT's) to estimate stock specific marine survival and fishery specific exploitation rates. The magnitude of this effect will scale with the number and magnitude of mark-selective fisheries.
- A Double Index Tag (DIT) approach was identified by the ad hoc Selective Fisheries Evaluation Committee as the primary assessment method to evaluate the effects of MSFs on survival of marked and unmarked fish. The DIT approach involves releasing two uniquely coded wire tagged groups of fish reared under exactly the same conditions, of which one group is adipose fin clipped.
- Coho DIT experiments from eight streams have marked more than five million Coho and recovered over 85,000 estimated tags at escapement. These data, analyzed with a risk ratio approach, suggest that although there may be an average 12% survival benefit (unmarked to marked risk ratio of 1.12 with an approximate 95% C.I. of 0.75 to 1.60) confidence intervals bridge a value of 1.0 indicating the possibility of no difference.
- A Bayesian hierarchical analysis, however, indicated that overall, there is a 70% probability that there is a positive survival benefit of being unmarked.
- A simple model integrating estimates of marked Coho exploitation rates from hatchery indicator stocks and average survival benefits of mark-selective fisheries suggest that exploitation rates on unmarked Coho are low; approximately 70% less, on average, than the exploitation rates estimated for marked Coho.
- Catch and assessment data are generally not of fine enough resolution to conduct MSF analyses at the stock level, limiting their application. An increased level of support for MSF, including the convention of an oversight committee familiar with current limitations, is recommended.

INTRODUCTION

Declines in the abundance of southern British Columbia Coho salmon populations, in particular Interior Fraser River Coho (IFR) salmon, through the 1990's, resulted in harvest restrictions for Coho in all sectors beginning in 1998. Mark-selective fisheries (MSFs) were implemented along with a domestic operational target exploitation rate ceiling for IFR Coho Salmon. In 1999, Coho

MSFs were implemented in select pilot areas; allowing the harvest of marked (adipose fin clipped) hatchery produced Coho with mandatory release of wild or non-marked Coho. By 2003, Coho MSFs were expanded to include almost all of southern B.C. recreational salmon fisheries with non-retention of wild Coho, as well as the West Coast Vancouver Island (WCVI) troll fishery at some times of year (e.g. September).

The management objective of MSFs is to allow the retention of marked, often hatchery-produced, fish while having a reduced impact relative to a non-mark-selective fishery on unmarked, usually wild, fish. Minimizing impact on wild fish is important as they often represent the portion of the population most valuable for maintaining genetic diversity or other conservation objectives, such as stock rebuilding. Theoretical evaluation and simulation modeling indicates that MSFs can reduce exploitation rates on unmarked fish relative to a fishery that is not mark-selective. Mortality rates for unmarked fish depend not on capture mortality, but mortality experienced from hooking and releasing, or from interaction with fishing gear that doesn't result in capture. A MSF will have a lower exploitation rate on unmarked fish than a non-MSF, as long as the mortality rate from release or gear interactions for unmarked fish is lower than the proportion of marked fish in the fished population. More explicitly, the benefit for unmarked fish of a MSF over a non-MSF is proportional to the difference between the rate of marked fish available in the fishery and the non-retention mortality rate in the fishery. Mixed bag fisheries will have less benefit for unmarked fish survival, dependent on the degree to which they differ from a pure mark-selective fishery. Fisheries managers should always ensure that the proportion of marked fish available for capture is higher, ideally much higher, than the expected non-retention mortality when considering MSFs as a directed management approach.

The primary concern around MSFs is they complicate assessment; particularly relative to the use of coded wire tags (CWT's) to estimate stock-specific marine survival and fishery specific exploitation rates. If not corrected for, the differential impact of MSFs on marked and unmarked fish would invalidate the assumptions required for survival and exploitation rate estimates from indicator stocks to apply to the unmarked stocks they are designed to represent.

This CSAS process specifically addressed five points defined in the Terms of Reference for the evaluation:

- Document the objectives of the MSF and the management measures undertaken to implement IFR Coho conservation starting in 1998 through 2014, with a focus on recreational marine fisheries in Canadian waters south of Cape Caution.
- Compile, analyze and report on recreational catch and effort metrics, coded wire tag (CWT) data, salmon enhancement and marking programs relevant to the assessment of the MSF objectives. Data prior to (pre-1998) and during the implementation of MSF, up to 2014, should be considered.
- Assess the effect of the MSF on catch, effort and estimated exploitation rates in the marine recreational fishery from 1998 through 2014; include commercial.
- Provide a summary of MSF evaluations conducted in other jurisdictions and consider relevant comparisons with this assessment.
- Consider the limitations, confounding factors and uncertainty in the results of this evaluation, including but not limited to the monitoring programs, assessment programs, and compliance with regulations.

ASSESSMENT

Method Overview

Data held by DFO related to mark-selective fisheries were reviewed, including:

1. Hatchery Coho production data from the Salmonid Enhancement Program (SEP), including releases of marked and unmarked hatchery-reared Coho salmon before and after the implementation of MSFs. Data represent all SEP-sanctioned facilities enhancing Coho stocks south of Cape Caution, including all major and minor facilities in the Fraser River system. A time-series of hatchery-reared Coho, including mark status, was developed from these data for brood years 1968 to 2012. These data included all released progeny at the time of analysis.
2. Data from recreational and commercial MSFs. Recreational effort and Coho catch estimates for marine areas south of Cape Caution were extracted from the Catch and Release Estimate Tool (CREST) database from 1980 to 2014. Catch estimates refer to both released and retained catch unless otherwise noted. Because of survey distributions in time and space, only Johnstone Strait and WCVI catch estimates for the period 2000 to 2014 were considered. Literature was reviewed on recreational hook and line release mortality for Coho salmon in particular and salmonids more generally. Data presented in Bartholomew & Bohnsak's (2005) comprehensive review were used to estimate mean and approximate confidence limits for hook and line release mortality in salmonids.
3. Mark-selective Coho fishery data are only available for Area G commercial troll fisheries on the West Coast of Vancouver Island. Commercial Coho catch estimates since 2001 were queried from the Fisheries Operating System (FOS) database. To estimate fishery-specific mark rates, the study assumed that during MSFs all retained Coho were marked and all released Coho were unmarked.
4. Double Index Tag (DIT) results from SEP and the Mark Recovery Program. Double Index Tag (DIT) release and recovery data were queried from the DFO Enhancement and Planning Assessment Database. Odds ratios measure the relative survival of unmarked fish to marked fish where odds ratios >1 indicate higher relative survival and <1 lower survival.

The appropriate data were applied, in combination with estimates of exploitation rates from indicator stocks and models, to an evaluation of the use of MSFs for Coho. Specifically, a risk ratio approach was used to evaluate the benefit of an MSF to unmarked fish when considered against a fishery with no mark selection.

Return rates of unmarked to marked Coho ratios were estimated to evaluate the impact of MSFs. The relative return rate was measured as the rate at which unmarked and marked Coho were found returning as adults to the stream where they were released to spawn. This return rate is a surrogate for overall survival rate, and integrates across the impacts of all natural and fishing mortality, including all mark-selective fisheries. Any difference in the relative return rate of unmarked and marked fish is assumed to result from differential mortality in mark-selective fisheries, as the rearing conditions and release of the Double Index Tag (DIT) pairs were identical. One measure of these differences is a risk ratio approach where the return rate of unmarked fish (returning adults divided by releases) is scaled (divided by) the return rate of marked fish. Risk ratios larger (or smaller) than one indicate a relative return rate (survival) higher (or lower) for unmarked Coho.

A hierarchical Bayesian approach was also used to analyze risk ratios. The method employs an alternative method of estimating the actual probability that a benefit from MSFs actually exists.

Results

Estimates of the benefit of MSFs for unmarked Coho from DIT analyses were similar to estimates from Washington State. The Joint Coho DIT Analysis Workgroup found average differences of 9.3% (range 3.5 to 15.7% when averaged by brood year and 1.5 to 14.1% when averaged across years by release location) in favour of unmarked Coho in brood years 1995 through 1998 (JCDAW 2003). Their estimates of 95% confidence intervals highlight the low precision of these relative survival estimates and often included an odds ratio of 1.0.

The by stream risk ratio results are highlighted in Table 1. This table demonstrates that the across stream hyper-distribution of risk ratio estimates (equivalent to a weighted average across streams) are consistent with a benefit of MSFs for unmarked fish of 24% (one minus the risk ratio of 1.24) with a posterior probability of 63%. This result is highly uncertain, ranging from a cost of 49% to a benefit of 151% in terms of relative return of unmarked relative to marked fish. The stream-level effect of MSFs on the relative return of unmarked fish was highest for streams that are no longer acting as DIT indicators. The stream level estimates for the two streams that continue to release DIT pairs (Inch and Chilliwack) have much lower risk ratios over the fifteen years of estimates from those two streams. Likely a more realistic approach to estimating the overall impact of MSFs is to conduct the analysis by return year (Table 2).

The hierarchical Bayesian return-year analysis (Table 2) indicates that the benefit of mark-selective fisheries on relative return of unmarked to marked Coho from DIT streams is 12% with a posterior probability of 70% (ranging from a cost of 25% to a benefit of 60%) over Coho returning from 1999 to 2013. Unfortunately, only two streams have DIT releases for the last eight years of the assessment period (2006-2013 return years); however, this is the best estimate of the relative return rate of unmarked to marked Coho as a result of MSFs.

Table 1. Average marked to unmarked risk ratios for escapement of Double Index Tag (DIT) groups for the six Canadian DIT systems with escapement data. The "Posterior P RR >1" indicates the probability that the risk ratio is greater than one, which would indicate a survival benefit for unmarked relative to marked fish.

STOCK	DIT release years	DIT recovery & estimate years	Continuing DIT program?	Mean umarked to marked Risk Ratio	lower CI	Upper CI	Posterior P RR > 1
Big Qualicum	7	7	No	1.31	0.48	3.00	0.63
Chilliwack	7	7	No	1.29	0.57	2.55	0.69
Goldstream	7	3	No	1.40	0.28	4.37	0.56
Inch	15	15	Yes	1.17	0.74	1.81	0.72
Quinsam	15	15	Yes	1.12	0.75	1.62	0.70
Robertson	7	7	No	1.25	0.41	3.02	0.60
Sooke	2	0	No	-	-	-	-
Spius	6	6	No	1.26	0.42	2.81	0.58
Combined	**-**	***60***	**-**	***1.24***	***0.51***	***2.51***	***0.63***

Table 2. The unmarked to marked risk ratios by return (fishery) year over active Canadian DIT streams, with 95% confidence intervals. The "# DIT ests." refers to the number of stock-specific DIT estimates in each return year. The "Posterior P RR >1" indicates the probability that the risk ratio is greater than one - which would indicate a survival benefit for unmarked relative to marked fish, consistent with a positive survival benefit of MSFs.

Return year	Mean	Lower CI	Upper CI	# DIT ests.	Posterior P RR > 1
1999	1.17	0.59	2.06	6	0.658
2000	1.14	0.58	2.05	7	0.581
2001	1.08	0.42	2.46	6	0.475
2002	1.14	0.55	2.11	7	0.582
2003	1.20	0.57	2.33	6	0.631
2004	1.21	0.70	1.99	6	0.738
2005	1.35	0.50	2.94	6	0.678
2006	1.31	0.40	3.29	2	0.593
2007	1.21	0.58	2.12	2	0.673
2008	1.24	0.56	2.33	2	0.663
2009	1.18	0.59	2.16	2	0.642
2010	1.19	0.52	2.44	2	0.599
2011	1.13	0.63	1.94	2	0.636
2012	1.21	0.48	2.68	2	0.597
2013	1.13	0.49	2.45	2	0.536
Combined	***1.12***	***0.75***	***1.60***	***60***	***0.700***

Sources of Uncertainty

- Confidence intervals for DIT analyses by stock or by year consistently include a value of 1.0, indicating an inconclusive result for the test of MSF effect on increased survival of unmarked fish. Bayesian probability statements associated with each case do provide a weighted measure of uncertainty.
- Assessment data specific to certain stocks, and hatchery production are typically unavailable, limiting the specificity of analyses.
- Creel survey data are inherently variable due to the nature of voluntary reporting of catches.
- Capture, release, and post-release mortality data are typically not aligned to fishery regulation areas, meaning results cannot be applied specifically to individual fisheries. This is a source of uncertainty in providing advice relative to specific fisheries.

CONCLUSIONS AND ADVICE

- There is evidence, though inconclusive, that a MSF benefit exists for Interior Fraser River Coho stocks.
- The confidence intervals associated with the DIT analysis are applicable to the catch rates under which data were gathered. Higher catch rates may be associated with increased management risks.
- MSFs are a potentially powerful tool, but currently lack the proper data support to realize their full management benefit. Improved support to MSF efforts should include solutions to outstanding sources of uncertainty, including improved assessment data, better monitoring of recreational submissions, improved research on release mortality rates, and alignment of data monitoring to fisheries regulation areas.
- Formation of a working group to evaluate the DIT program is recommended, including a specific program for IFR Coho. This group should be composed of members who will understand the barriers to implement a DIT program with full functionality.
- The last review of release mortality rates was undertaken in 2001. A new review is warranted, which should indicate imminent research needs.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 3-5, 2015 regional peer review on the Evaluation of Marine Recreational Coho Mark-selective Fisheries in British Columbia, including an evaluation of the Canadian marine fishery exploitation model for Interior Fraser Coho. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Bartholomew, A. and J. A. Bohnsack. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15: 129-154.

Joint Coho DIT Analysis Workgroup (JCDAW). 2003. Analysis of Coho Salmon Double Index Tag (DIT) Data for the Brood Years 1995-1997. Northwest Fishery Resource Bulletin 2003 Project Report Series No. 12. 159 p.

THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Telephone: (250) 756-7208
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
© Her Majesty the Queen in Right of Canada, 2015

Correct Citation for this Publication:

DFO. 2015. Evaluation of Marine Recreational Coho Mark-Selective Fisheries. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/057.

Aussi disponible en français :

MPO. 2015. Evaluation des pêches maritimes récréatives et sélectives du saumon coho. Secr. can. de consult. sci. du MPO, Avis sci. 2015/057.